Chapter 3. ENVIRONMENTAL SETTING

3.1 General

Pacific herring, *Clupea pallasi*, are found throughout the coastal zone from northern Baja California on the North American coast, around the rim of the North Pacific Basin and Korea on the Asian coast (Outram and Humphreys 1974, Hart 1973). In California, herring are found offshore during the spring and summer months foraging in the open ocean. Beginning as early as October and continuing as late as April, schools of adult herring migrate inshore to bays and estuaries to spawn. Schools first appear in the deep water channels of bays to ripen (gonadal maturation) for up to two weeks, then gradually move into shallow areas to spawn. The largest spawning aggregations in California occur in San Francisco and Tomales bays. San Francisco Bay is also near the southern end of the range for Pacific herring (Miller and Schmidtke 1956).

Spawning occurs in the intertidal and shallow subtidal zones. Males release milt into the water column while females extrude adhesive eggs on a variety of surfaces including vegetation, rocks, and man-made structures such as pier pilings, boat bottoms, rock rip-rap, and breakwater structures. Embryos (fertilized eggs) typically hatch in about ten days, determined mainly by water temperature. Larval herring metamorphose into juvenile herring in about ten to twelve weeks. In San Francisco Bay, juvenile herring typically stay in the Bay through summer, and then migrate out to sea. Where juvenile herring migrate to once they leave the bays and estuaries is not known or understood.

Most of the herring fisheries occur during the spawning season. The roe herring or gill net fisheries catch herring as they move into the shallows to spawn when the eggs are ripest. The product, *kazunoko*, from this fishery is the sac roe (eggs) in the females which are processed and exported for sale to Japan. California's roe herring fisheries occur in the Crescent City Harbor area, Humboldt Bay, Tomales Bay, and San Francisco Bay.

The San Francisco Bay herring eggs-on-kelp fishery suspends Giant kelp, *Macrocystis pyrifera*, from rafts for herring to spawn on. The kelp is harvested

near the Channel Islands and/or in Monterey Bay and then transported to San Francisco Bay. The product of this fishery is the egg-coated kelp blades that are also processed and exported to Japan. This product, *komochi* or *kazunoko kombu*, is served as an appetizer typically during New Year's celebrations

The only existing ocean fishery for herring in California occurs during the non-spawning season in Monterey Bay. Landings from this fishery enter the aquarium food and bait markets. Small fisheries for fresh fish are also permitted during the non-spawning season in Tomales Bay and San Francisco Bay.

Herring are a food source for many species of birds, fish, invertebrates, and mammals. Predation is particularly high during spawning when adult fish and eggs are concentrated and available in shallow areas. Predation by birds and fish during the egg stage, when eggs are deposited in the intertidal and shallow subtidal zones, is a significant cause of natural mortality for herring.

The roe herring fishery in California has been intensively regulated since its inception in 1973, at first by the California State Legislature, then by the Fish and Game Commission (Commission). Department of Fish and Game (Department) estimates of the spawning population biomass have provided a critical source of information used for establishing fishery quotas to control the harvest of herring and provide for the long-term health of the herring resource. Annual estimates of spawning biomass are made by the Department in Tomales and Humboldt bays using egg deposition surveys.

In San Francisco Bay, spawning biomass was estimated by the Department using spawn deposition surveys from 1974 through 1989; from 1990 through 2003 the Department estimated spawning biomass from a combination of spawn deposition and hydroacoustic surveys. For the 2003-04 season, the spawning biomass estimate was derived from the spawn deposition surveys alone (See Section 3.3.1). In addition to the estimates of spawning biomass, the Department collects fishery independent age composition data from the population, as well as fishery dependent age composition from the commercial catch. All of the information collected by the Department, including ocean conditions, is used in annual population assessments.

A thorough description of the environmental setting is provided in Chapter 3 of the 1998 Final Environmental Document (FED), which includes Pacific herring life history, ecology, status of stocks and fisheries at that time, and biological and environmental descriptions of herring fishery locations (Crescent City area, Humboldt Bay, Tomales Bay, San Francisco Bay, and Monterey Bay).

3.2 Status of the San Francisco Bay Spawning Population

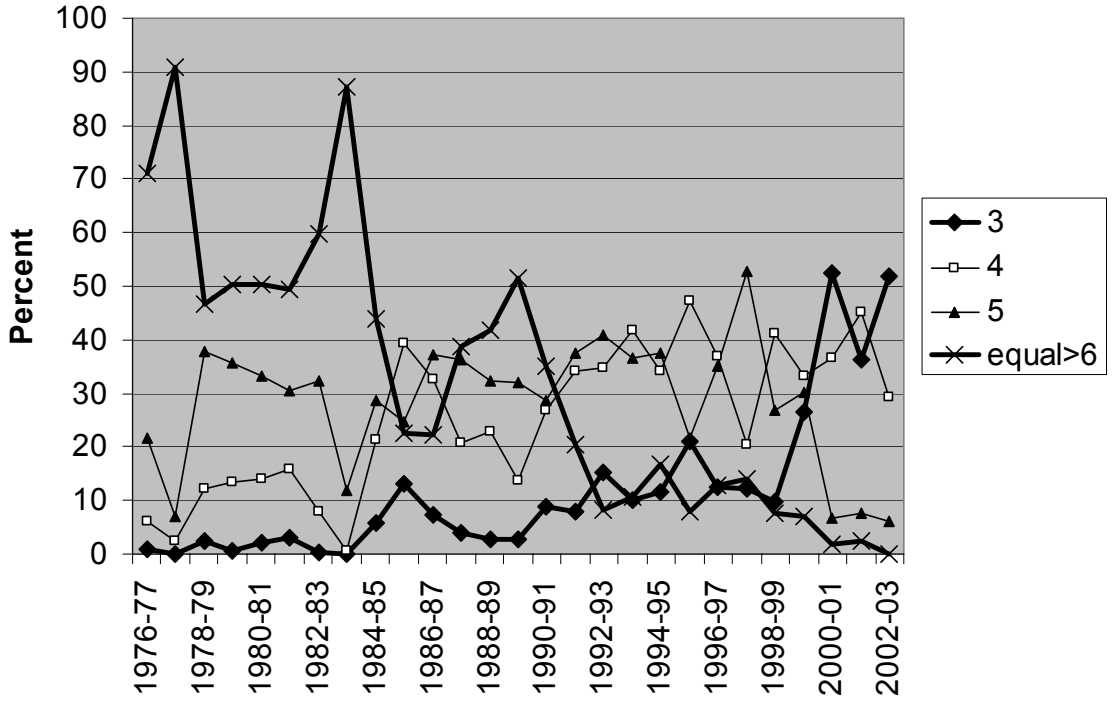
Following the 2002-03 herring season, Department biologists conducted a comprehensive review of the status of the San Francisco Bay herring population. The review included an analysis of several long-term data sets, some of which date back to the beginning of the roe fishery in 1973, including spawning biomass estimates, age composition of the population, age composition of the catch, length and weight at age, and environmental data. In addition, a stock assessment model, called Coleraine, was utilized to assess the status of the population. The Department's use of the Coleraine model and its results were subjected to an independent peer review, administered through California Sea Grant (Section 3.3.1). Three key indicators of a depressed stock, which have been developing over a number of years, were identified for the San Francisco Bay population:

1. Spawning biomass has remained well below the long-term average since the 1997 El Niño (Figure 2.2). Results of the Coleraine model indicate that the San Francisco Bay population has declined in size to roughly 20 percent of its unfished level.
2. Older ages (five years and older) are disappearing from the population (Table 3.1). San Francisco Bay herring have been aged as old as nine years in the past. Over time, the numbers of herring at age five and older have declined considerably; in the last several years virtually no herring aged seven or older have been found and the number of five and six year old herring are at very low levels. The decline in older ages has forced the gillnet fishery to increasingly depend on fewer and

younger age groups (primarily age four herring) to support it, resulting in higher fishing mortality on those younger age groups (Figure 3.1). Until the mid-1980s, more than 50 percent of the gillnet catch was comprised of age six and older herring; presently these ages are no longer supporting the fishery, falling well below 10 percent of the catch. In addition, age three herring, virtually nonexistent in the gillnet catch in the past, have increased in recent years. This is cause for concern as the Department's management strategy has been to avoid the harvest of age two and age three herring, many of which are coming into the bay to spawn for the very first time.

3. Recruitment of a strong year-class of herring to the population and fishery has not been observed since before the 1997 El Niño. With the decline of older age groups in the population, the San Francisco Bay stock has needed strong recruitment to replenish the stock.

Figure 3.1. Percent Gill Net Catch by age group from the 1976-1977 through 2002-2003 seasons



3.2.1 Peer Review of Age Structured Model and Survey Methods for San Francisco Bay

Because the Coleraine stock assessment model (Section 3.2) had not been previously used by the Department to assess the status of Pacific herring, the Department requested an independent peer review of its use of the model through California Sea Grant. In addition, the Department requested that the peer review also evaluate the two survey methodologies (spawn deposition and hydroacoustic) used to estimate Pacific herring spawning biomass in San Francisco Bay. California Sea Grant assembled a panel of scientists with demonstrated expertise in modeling and assessing pelagic fish populations to provide the review.

In addition to reviewing the use of the Coleraine model, the peer review panel used two other models to assess the status of the San Francisco Bay herring population: an equilibrium surplus production model and a catch-age model used for Canadian herring management. Results of the three models were very similar. Reviewing model results and Department data, the peer review panel found that the San Francisco Bay herring population has been reduced to roughly 20 percent of its unfished level and is presently at or near its lowest abundance since the 1970s. The panel also found that the age composition of the catch has shifted over time towards younger herring. The panel recommended that a rebuilding policy be implemented. Other recommendations included: a re-evaluation of the harvest strategy, investigating the use of a threshold level for fishery closure, developing a specialized herring stock assessment model, and re-structuring the sampling program used in assessing age structure.

In reviewing the Department's biomass survey methodologies, the peer review panel found that the spawn deposition survey tends to underestimate biomass by about 10 percent and the hydroacoustic survey tends to overestimate biomass by about 20 percent. The panel found that the Department's method of combining the two surveys, which often involved using the higher of the two

estimates on a school by school basis, has contributed to excessive quotas by overestimating biomass. The panel recommended that the spawn survey be used as the primary index of abundance and as the biomass estimate for setting the fishery quota until an integrated catch-age model can be developed and verified for San Francisco Bay. They also recommended that hydroacoustic surveys be continued to support the location and timing of the spawn deposition survey in conjunction with sampling herring schools that are critical for collecting population age structure information.

3.2.2 San Francisco Bay Spawning Biomass Estimate and Age Structure

The 2003-04 spawning biomass estimate is 34,400 tons including the catch. Based on the Department's continued concerns about the status of the San Francisco Bay herring population and the recommendations of the peer review panel, the biomass estimate for the 2003-04 season is based on the spawn deposition survey alone; rather than a combined estimate using both the spawn deposition and hydroacoustic survey estimates. Using the spawn deposition surveys alone represents a change in the Department's methodology, first implemented in the 1990. This change is being implemented by the Department as a conservative management measure.

This spawning biomass estimate for San Francisco Bay is 33.2 percent below the 27-year average of 50,071 tons. Thirteen spawning events, grouped into seven spawning waves, were documented in San Francisco Bay for the 2003-04 season. From these spawns, a total of 32,832 tons of spawn escapement were estimated, and added to 1,568 tons of sac roe herring and herring-eggs-on-kelp product converted to whole fish for the total spawning biomass estimate of 34,400 tons.

The first spawn was detected in late November in Richardson Bay and the last spawn occurred in mid-March in Richardson Bay as well. Spawns ranged in size from trace amounts to 11,161 tons. The majority of spawning biomass for the season occurred in February (11,546 tons, 33.6 percent) and January (10,805 tons, 31.4 percent), followed by March (10,565 tons, 30.7 percent), December (1,456 tons, 4.2 percent), and November (40 tons, 0.1 percent). Historically, the majority of

spawning on average has occurred in January, followed by December and February (Watters et al. 2004). Because older herring tend to be more abundant in the early part of the spawning season (Figure 3.6, 1998 FED), the shift in spawning biomass toward February and March during 2003-04 may reflect the younger age composition of the population.

One of the Department's fishery management goals is to allow the harvest of age four and older herring and to avoid the harvest of two and three year old herring which are entering the Bay to spawn for the first time. However, since the 1997-98 El Niño, there has been a decline in the estimated number of age four and older herring and a corresponding increase in the number of three year old herring in the catch.

The preliminary estimated age composition (based on lengths) of the 2003-04 San Francisco Bay population indicates that young herring dominated the spawning population (Table 3.1). One- two- and three-year-old sized herring composed approximately 83 percent by number of the spawning biomass. Preliminary estimates of older fish, including 4-year-olds, were well below long-term average abundances, continuing a period of decline observed since the 1997-98 El Niño season.

The preliminary estimated age composition (based on lengths) of the 2003-04 commercial gill net catch indicates that 4- and 5-year-old sized fish comprised approximately 50 percent and 35 percent by number, respectively, of the catch. Three-year-olds composed 15 percent of the catch by number, and 6- and 7-year-old sized fish do not appear to be present in the catch at all. The percentage of 3-year-old herring in the catch declined from recent years and the percentage of 4- and 5-year-old herring increased. However, this change in catch composition is derived from length-based preliminary ages and may change when the fish are aged from their otoliths. The age composition of the spawning population and the catch based on otolith readings will be presented in the Final Supplemental Environmental Document (FSED).

Table 3.1. Estimated Numbers (x 1,000) of Herring-at-Age in the San Francisco Bay Spawning Population, 1982-83 to present

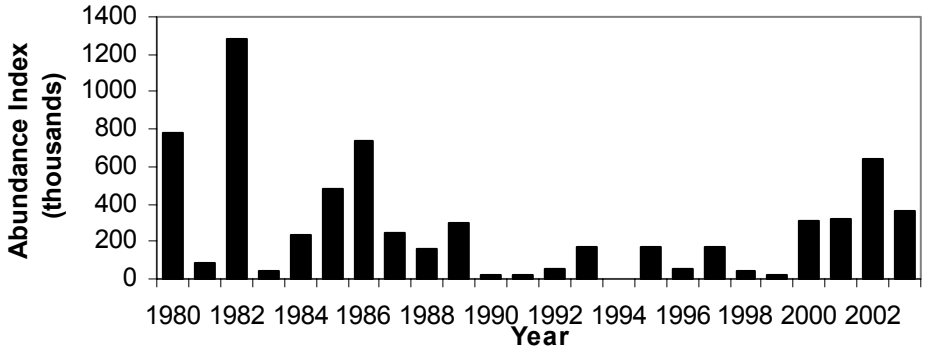
	Age and Percent Composition																	
Season	**1**	**%**	**2**	**%**	**3**	**%**	**4**	**%**	**5**	**%**	**6**	**%**	**7**	**%**	**8**	**%**	**9**	**%**
82-83	[a]	N/A	87,908	14.8	149,971	25.2	182,936	30.7	118,040	19.8	30,478	5.1	17,177	2.9	8,121	0.4	797	0.1
83-84	[a]	N/A	332,699	56.5	69,654	11.9	92,565	15.8	73,840	12.6	17,306	2.9	1,168	0.2	117	<0.1	0	0
84-85	[a]	N/A	184,695	38.7	190,998	40.0	46,613	9.8	22,153	4.6	25,914	5.4	6,652	1.4	688	0.1	0	0
85-86	[a]	N/A	162,422	32.4	160,613	32.1	126,535	25.3	26,790	5.3	16,038	3.2	7,752	1.5	717	0.1	182	<0.1
86-87	[a]	N/A	168,962	29.2	194,365	33.6	134,528	23.2	64,598	11.2	9,182	1.6	6,175	1.1	1,065	0.2	246	<0.1
87-88	[a]	N/A	233,193	30.6	292,508	38.3	136,604	17.9	66,494	8.7	25,337	3.3	5,027	0.7	3,939	0.5	0	0
88-89	[a]	N/A	146,525	25.8	222,058	39.0	139,906	24.6	44,435	7.8	12,310	2.2	3,030	0.5	534	0.1	0	0
89-90	[a]	N/A	294,631	37.6	237,377	30.3	136,248	17.4	84,361	10.8	23,970	3.1	6,572	0.8	0	0	0	0
91-92	1,356	0.3	13,666	3.0	126,016	28.0	206,930	45.2	82,870	18.1	23,764	5.2	3,490	0.8	0	0	0	0
92-93	0	0	48,925	20.5	50,398	21.1	79,045	33.1	51,713	21.7	8,642	3.6	0	0	0	0	0	0
93-94	11,485	2.6	22,403	5.1	134,870	31.0	160,335	36.9	63,331	14.6	25,926	6	4,808	1.1	355	0.1	0	0
94-95	2,276	0.5	39,363	9.0	236,783	54.1	94,833	21.7	42,850	9.8	18,223	4.2	3,196	0.7	0	0	0	0
95-96	3,142	0.3	483,164	38.9	359,357	29.0	282,069	22.7	81,768	6.6	28,904	2.3	1,687	0.1	0	0	0	0
96-97	1,184	0.1	290,497	29.1	359,459	36.0	183,370	18.4	120,029	12.0	33,098	3.3	8,935	0.9	270	<0.1	0	0
97-98	42	0.01	45,092	17.2	129,411	49.3	65,637	25.0	18,724	7.1	2,259	0.9	1,430	0.5	0	0	0	0
98-99	1,931	0.4	256,816	52.0	54,306	11.0	114,835	23.2	56,915	11.5	9,729	2	558	0.1	978	0.2	[b]	0
99-00	1,440	0.4	103,490	30.4	154,260	45.3	48,150	14.1	29,000	8.5	4,310	1.3	0	0	0	0	[b]	0
00-01	56,773	11.3	133,086	26.4	242,143	48.1	62,054	12.3	7,922	1.6	1,584	0.3	0	0	0	0	0	0
01-02	5,788	1.5	157,182	39.6	138,752	35.0	75,088	18.9	15,383	3.9	4,265	1.1	152	0.04	0	0	0	0
03-04[c]	8,623	1.9	200,451	44.6	166,119	37.0	52,883	11.8	20,175	4.5	724	0.2	0	0	0	0	0	0
Mean	**7,837**	**1.6**	**170,258**	**28.3**	**183,471**	**35.5**	**121,058**	**22.3**	**54,570**	**9.3**	**16,098**	**2.7**	**3,890**	**0.6**	**839**	**0.1**	**68**	**0.1**

Note: 1990-91 season was not included due to incomplete data set for that season; 2002-03 season spawning biomass estimate unresolved.
[a] 1-year-olds were excluded, [b] 1- and 9-year-olds excluded, [c] preliminary length based age composition.

3.2.3 San Francisco Bay Herring Young of the Year (YOY)

Pacific herring young-of-the-year (YOY) are commonly caught by the Department's Central Valley Bay-Delta Branch San Francisco Bay Study (SFBS) during the spring and summer of each year. The SFBS conducts surveys to determine the abundance and distribution of invertebrates and fishes in the Western Delta and San Francisco Bay. Stations are sampled using a variety of research nets and other equipment, including a midwater trawl that is towed obliquely through the water column to capture species inhabiting varying depths. An index of abundance is calculated for YOY Pacific herring (Interagency Ecological Program Technical Report 63).

Figure 3.2 San Francisco Bay Herring YOY Abundance Indices: 1980-2003



The herring young-of-the-year (YOY) abundance index for 2003 continues to show improvement over pre-2000 levels. The strength of the YOY indices for the 2000 to 2003 year classes may indicate favorable environmental conditions for YOY survival and growth within San Francisco Bay. They also indicate an increase in the availability of YOY herring as food to other species in the Bay. However, there is no predictive relationship between the YOY abundance index and the subsequent numbers of two and three year-old herring that return to spawn. Survival to first reproduction is affected by a number of factors during the first two to three years of life, including predation, food availability, and

competition.

3.3 Status of the Tomales Bay Spawning Population

The 2003-04 herring spawning biomass estimate for Tomales Bay is 12,124 tons, which is 177 percent more than the 2002-03 biomass estimate of 4,382 tons. This estimate is the largest since the re-opening of the Tomales Bay roe herring fishery in the 1992-93 season exceeding the average biomass since by 199 percent. It is the second largest spawning biomass estimate recorded since the Department began conducting annual population assessments in Tomales Bay following the opening of the fishery in the 1972-73 season (Table 3.2).

The Tomales Bay herring fishery was closed after a record low 167 tons of spawning escapement in the 1988-89 season, which followed several seasons of low spawning and herring abundance (Table 3.2). During the Tomales Bay herring fishery closure (1989-90, 1990-91, and 1991-92 seasons), fishing was allowed to continue in the outer Bodega Bay. The inner portion of Tomales Bay fishery re-opened for the 1992-93 season following improvements in spawning during the closed period; however, this recovery was not entirely attributed to recruitment of younger fish. Population data collected by the Department indicated that the increase in the numbers of older herring in Tomales Bay is most likely due to immigration to the Tomales Bay spawning population from other locations.

Since the 1992-93 season, spawning biomass estimates fluctuated after an initial increase and then declined to a post-closure low during the 1997-98 El Niño (586 tons) (Table 3.2). After the 1997-98 El Niño, the herring spawning biomass has shown a general trend towards improvement. Oceanic temperatures over the past few seasons indicate a cooling trend, which is often favorable to herring. The weak to moderate 2002-03 El Niño did not appear to negatively affect herring in Tomales Bay in 2003-04.

There were six spawning events during the 2003-04 season in Tomales Bay, which totaled an estimated 11,844 tons of spawning escapement. Twenty-

five different spawning bed areas were utilized from December though March; although, spawning was confined primarily to the southern half of Tomales Bay. Historically, eelgrass has been used as a primary spawning substrate for herring in Tomales Bay. During the 2003-04 season, spawn on *Gracilaria* spp. accounted for 72 percent of the total estimated spawning escapement. The density of *Gracilaria* spp. within most bed areas this season was greatly reduced; however, there was an increase in the total area of *Gracilaria* spp. distribution compared to the prior two seasons.

In January 2004, the Department recorded a significant spawning event south of Millerton Point. This is the first record of a significant spawn in this area in 30 years of spawn deposition surveying in Tomales Bay. The combination of increased abundance of spawning substrate, specifically eelgrass, in this area, and the lower local salinities produced by increased freshwater inflow from Lagunitas Creek, may have contributed to more favorable conditions for spawning.

Based on research catch data, the demographics of the spawning population in Tomales Bay changed in the 2003-04 season. Research samples are collected using gill nets with several mesh sizes, which are designed to sample a broader size range than commercial gill nets. The average size of herring in the research catch during the 2003-04 season was smaller than the 2002-03 season, 171.5 mm body length (BL) and 175.5 mm BL, respectively. There was a greater percentage of small fish (< 170 mm) in the population than prior seasons, indicating potentially good recruitment. However, there was also an increased percentage of larger fish (>200 mm) appearing in research catches than in recent seasons. The decline of larger, older herring in the Tomales Bay population had been a concern since the 1997-98 El Niño, and while lesser in extent, was comparable to the phenomenon observed in the San Francisco Bay stock (see Section 3.2).

Changes in the size composition were indicated in the samples taken from the commercial fishery in 2003-04. The mean length of herring sampled from the commercial catch in 2003-04 was also larger than last season, 191.1 mm BL and

188.1 mm BL, respectively. The mean length of commercially caught herring surpassed the 190 mm BL mark for the first time in six seasons.

The Department is continuing a mesh size study for the Tomales Bay fishery. This study allows permittees to use a gill net mesh size of 2-inches, smaller than the 2 ⅛-inch mesh required by regulation. The Department is evaluating the effects of using 2-inch mesh on the age classes caught by the fleet to ensure that the younger fish (≤ 3-year-olds) are not taken. Although there was an increase in the proportion of smaller fish in the population in 2003-04, the commercial catch was composed primarily of larger fish (≥ 4-year-olds).

The population trends observed within the research and commercial catch data are desirable: the bulk of the population is composed of smaller fish (≤180 mm), but the majority of the commercial catch is supported by larger and older herring. Since the 1997-98 El Niño, the Tomales Bay herring spawning population has rebounded, due in part to favorable environmental conditions and low harvest levels. Recognizing that environmental conditions vary, the Department maintains a conservative fishery management strategy (closure of the outer bay fishery and conservative quotas) to help ensure the sustainability of the Pacific herring population in Tomales Bay.

Table 3.2. Tomales Bay Herring Biomass Estimates 1972-73 through 2003-04 Season.				
Season	**Spawn Escapement (short tons)**	**Catch (short tons)**	**Percent Catch (Exploitation Rate)**	**Spawning Biomass (short tons)**
Gillnet and Lampara Fisheries in Tomales Bay and Outer Bodega Bay				
1972-73	2,265	598	26.4	2,863
1973-74	6,041	521	7.9	6,562
1974-75	4,210	518	11	4,728
1975-76	7,769	144	1.8	7,913
1976-77	4,739	344	6.8	5,083
Gillnet Only Fishery - Tomales Bay and Outer Bodega Bay				
1977-78	21,513	646	2.9	22,159
1978-79	--	448	--	-- *
1979-80	5,420	603	10	6,023
1980-81	5,128	448	8	5,576
1981-82	6,298	851	11.9	7,149
1982-83	10,218	822	7.4	11,040
1983-84	1,170	110	8.6	1,280
1984-85	6,156	430	6.5	6,586
1985-86	435	771	12.8	6,000**
1986-87	4,931	867	15	5,798
1987-88	1,311	750	36.4	2,061
1988-89	167	213	56	380
Tomales Bay Gillnet Fishery Closed - Fishing in Outer Bodega Bay Only				
1989-90	345	0	0	345
1990-91	779	0	0	779
1991-92	1,214	0	0	1,214
Tomales Bay Gillnet Fishery Opened - Fishing in Outer Bodega Bay Closed				
1992-93	3,856	222	5.4	4,078
1993-94	2,244	219	8.9	2,463
1994-95	3,704	275	6.9	3,979
1995-96	1,704	355	17.2	2,059
1996-97	1,288	222	14.7	1,510
1997-98	586	0	0	586
1998-99	4,015	54	1.3	4,069
1999-00	1,969	42	2.1	2,011
2000-01	3,898	298	7.1	4,196
2001-02	6,889	354	4.9	7,243
2002-03	4,304	78	1.8	4,382
2003-04	11,844	280	2.3	12,124
AVERAGE	**4,400**	**359**	**9.5**	**4,911**

* No herring fieldwork this season.

**Biomass estimated by cohort analysis; for all other years, biomass was estimated from spawning-ground surveys.

3.5 Status of the Humboldt Bay and Crescent City Spawning Populations

The spawn escapement estimate for the 2003-04 Humboldt Bay herring spawning season is 505 tons. This is close to a three-fold increase over last season's estimate of 167 tons and 158 tons higher than the 8-year average from seasons when spawn assessments were conducted in Humboldt Bay.

Four separate spawn events occurred in Humboldt Bay during the 2003-04 season. The first spawn detected was in the North Bay on January 4, 2004 and was estimated at 155 tons. The next spawn took place in the South Bay on or near January 22, 2004. Empty egg cases, along with soon-to-emerge larval herring, were found over a large area of eelgrass on the west side of the Bay. Because this spawn event was discovered too late for Department biologists to obtain an accurate estimate of egg density, spawn escapement estimates from this event are not included in the season total. Therefore, this season's spawn escapement estimate of 505 tons should be considered low by several tons. The next spawn event occurred on February 2, 2004 in the North Bay and was estimated at 187 tons. The last spawn detected this season occurred in the South Bay on February 4, 2004 and was estimated at 155 tons.

Due to the low numbers of herring landed during 2003-04 season the Humboldt Bay commercial catch was not sampled. Additionally, biological data is not available for the 2003-04 season since no herring were caught by Department research nets. However, during the 2002-03 season herring were available to Department biologists from both commercial and research nets. The mean size of herring sampled from the commercial catch was 200 mm BL (range 187-216 mm); 10 mm below the fourteen-year average of 213 mm between 1978-1992 when commercial landings were routinely sampled in Humboldt Bay. The mean size of herring from the Department's research net averaged 188 mm BL (range 139-223 mm) during the 2002-03 season, slightly above the mean lengths from the 2000-01 and 2001-02 seasons of 187 mm and 184 mm, respectively.

Commercial landings for both the 2002-03 and 2003-04 seasons were far below the 22-year average of 39 tons with 1.8 and 0.6 tons landed, respectively.

A long-time Humboldt Bay herring permittee attributed these low landings to a disproportionate amount of small herring entering the bay which were unavailable to commercial 2 ¼-inch mesh nets used in Humboldt Bay. Landing data from the Department's research nets appear to coincide with this observation, as approximately 81 percent (by number) of the herring caught during the 2002-03 season were captured in meshes two inches or less. Although commercial landings in the Humboldt Bay herring fishery have been well below average the last two seasons, spawn assessments conducted by the Department during the same time period show that a significant number of herring were entering the bay to spawn.

The 2003-04 spawn escapement estimate of 505 tons, if used as a basis for setting the Humboldt Bay fishery quota, would result in a conservative exploitation level of 12 percent with a quota set at 60 tons. The 60-ton quota was set in regulation for Humboldt Bay beginning in 1983. The average spawn escapement from the 2000-01 through 2003-04 seasons is 417 tons. A 60-ton quota based on this average would result in a 14 percent exploitation level, also considered to be a conservative harvest level.

The Department continued to work with University of California Sea Grant, Humboldt State University, and the Humboldt Bay Harbor District to monitor eelgrass (*Zostera marina)* biomass in Humboldt Bay. Agencies completed a full-year of sampling with 12 sample sites in both the north, central and the south regions of Humboldt Bay. Above-ground eelgrass biomass (fresh weight) for winter 2003-2004 had a mean of 0.48 kg/m2 (range 0.29-0.97 g/m2), which is an increase of 24 percent from the winter 2002-2003 mean of 0.31 kg/m^2 (range 0.14-0.40 kg/m^2). This data is essential for herring research and has greatly improved the accuracy of the season's spawning biomass estimate.

Spawning ground surveys and commercial fishery assessments were not conducted in the Crescent City Harbor area for the 2003-04 season. No commercial fishing effort occurred in the Crescent City Harbor area during the 2003-04 season. The 30-year average catch of 22 tons is below the 30-ton quota for this fishery. The Department does not plan to conduct spawning ground

surveys or commercial fishery assessments in the Crescent City Harbor area for the 2004-05 season.

3.6 Fishery Threshold

The Department's continued concerns about the status of the San Francisco Bay herring population (Section 3.2) have led to renewed interest in establishing a threshold level below which fishery closure would be recommended. The concept of establishing a threshold for the San Francisco Bay fishery was introduced to the Director's Herring Advisory Committee (DHAC) in 1991. Development of a threshold was further discussed at the following year's DHAC meeting in 1992. This fishery management tool would provide objective criteria by which fishery closure would be recommended, in order to help rebuild the herring stock to a healthy level as swiftly as possible to reopen a fishery.

Threshold criteria currently being considered include: 1) a percentage of the long-term average total spawning biomass; 2) the lowest total spawning biomass from which the population recovered; 3) varying harvest levels with spawning biomass levels; and 4) a minimum level for the "catchable" based on the estimated proportion ("catchable biomass") level, rather than the total spawning biomass of the population exploitable by the gill net fleet. Other potential threshold criteria for fishery closure will be considered as Department research on the subject continues.

The long-term average spawning biomass estimate for the San Francisco Bay population since subtidal spawns were included is 50,071 tons (Table 3.3). A threshold based on 50 percent of this long-term average is 25,036 tons. In three seasons, 1992-93, 1997-98, and 2002-03, the spawning biomass dropped below this level. The Department proposed fishery closure for the 1993-94, 1998-99 and 2003-04 seasons to the Fish and Game Commission.

Table 3.3 San Francisco Spawning Biomass Estimates: 1978 to present	
Season	**Spawning Biomass Estimate**
1978-79	36,700
1979-80	53,000
1980-81	65,400
1981-82	99,600
1982-83	59,200
1983-84	40,800
1984-85	46,900
1985-86	49,100
1986-87	56,800
1987-88	68,900
1988-89	66,000
1989-90	64,500
1990-91	51,000
1991-92	46,600
1992-93	21,500
1993-94	39,900
1994-95	40,000
1995-96	99,050
1996-97	89,570
1997-98	20,000
1998-99	39,500
1999-00	27,400
2000-01	37,300
2001-02	35,400
2002-03	13,318
2003-04	34,400
Average	**50,071**

3.7 Areas of Controversy

Several areas of controversy are outlined in summary section S.6 of this DSED. In particular, item numbers 7 through 9 are relevant for the 2004-05 season and have been of concern to the Department and the commercial herring industry for the past several seasons.

Item number 7, status of the herring population in San Francisco Bay, is discussed in detail in Section 3.2 above. The Department has been concerned about the status of the San Francisco Bay stock for several years. A below average biomass coupled with a lack of older age fish to support the commercial

fishery, as well as a lack of strong recruitment, underline the Department's concerns and point to the continuance of a conservative management strategy and the implementation of management measures to support rebuilding the stock.

Item number 8, change survey methodology for assessing the population, refers to the Department's decision to use the spawn deposition survey as the primary index of abundance and as the biomass estimate for setting the fishery quota until an integrated catch-age model can be developed and verified for San Francisco Bay (See section 3.2.1 above). Controversy surrounding this decision involves the opinion of some herring industry representatives that the Department is underestimating the spawning biomass. Given the Department's concerns regarding the status of the San Francisco Bay herring stock and the findings of the peer review panel regarding the tendency for overestimating when combining the two surveys, the Department believes that a more conservative approach is warranted in order to support rebuilding the San Francisco Bay stock.

Item number 9, mesh size reduction in San Francisco Bay, involves the long term opinion held by some members of the commercial herring industry that a smaller mesh size would enable the fishery to catch the quota more efficiently without catching a large proportion of younger age fish (age 3 and younger). As mentioned above in section 3.2.2, not all age classes are currently represented in the population (lack of older age class fish) and age 3 fish currently comprise at fifteen percent of the commercial catch (2003-04 preliminary age based on length) and have comprised up to fifty percent of the catch in past seasons (Figure 3.1). The Department is concerned that a fleet-wide reduction in mesh size could further stress the already depressed San Francisco Bay stock. The Department does not support a fleet-wide reduction in mesh size at this time due to concerns regarding the condition of the stock discussed above.